2016-2018 Tennessee Garden Vegetable Trials: Performance of Grafted and Ungrafted Tomatoes

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Introduction and Overview

Successful residential vegetable production can differ from fresh-market commercial production. Yield is important, but not always the central metric for many gardeners. Others factors, such as quality, are important and success can also depend on crops being able to be produced without extremely high management requirements. This criteria can certainly differ by gardener, but a key facet is disease resistance that enables gardeners to produce crops without heavy losses to soil-borne disease or the burden of frequent pesticide applications.

Considering these factors, the opportunity for gardeners to utilize tomatoes with disease resistance or increased production through the use of a rootstock is currently of interest. The cost of grafted plants is higher, but gardeners may be willing to pay for more reliable production. Likewise, productivity increases could enable gardeners to reduce the size of their management area or dedicate garden or bed space to other crops. This project was designed to evaluate the performance of tomato cultivars both grafted and ungrafted in Tennessee conditions to aid gardeners in determining the potential to use grafted plants in their gardens.

Materials and Methods

Seedlings:

Tomato transplants, both grafted and ungrafted were produced by Plug Connection (Oxnard, CA). To ensure identical ages and optimum comparisons of grafted and ungrafted plants, they were ordered of similar ages and arrived in Knoxville on 20 April, 2016, 5 April, 2017, and 31 March, 2018.

In 2016, two determinates, consisting of one heirloom (‘Homestead’) and one F1 hydrid (‘Celebrity’) were grown along with two indeterminates consisting of one heirloom (‘Brandywine’) and one F1 hybrid (‘Big Beef’). In 2017, only ‘Big Beef’ and ‘Celebrity’ were grown. In 2018, all indeterminates were grown. ‘Big Beef’ was retained along with the heirloom cultivars of ‘Pineapple’ and ‘Cherokee Purple’. All grafted plants were placed on the rootstock ‘Emperador’ in both years. Grafted and ungrafted plants arrived in plug trays and were held in the UT Plant Sciences glass greenhouse until transplanting to 36 count, deep cell trays. Prior to transplanting in the field, plants were grown in a plastic covered heated greenhouse and then hardened off in a shaded cold frame before being transitioned to outdoor conditions.

Field establishment and management:

Trial plots were located at the East Tennessee Research and Education Center (ETREC), Organic Crops Unit (OCU) in plot L, which is a non-certified plot. Soil tests were taken ETREC personnel and fertilization was applied according to soil tests results prior to plot establishment. The study area consisted of four (2016) and two (2017) 175 ft long rows on 5 ft centers (2016) and 6 ft centers (2017, 2018). These rows were covered in black plastic with drip irrigation installed at bed establishment.

Four replications of each cultivar x rootstock treatment were placed in a randomized complete block design containing a total of 32 plots in 2016, 16 plots in 2017, and 24 plots in 2018. Each plot consisted of 6 plants in both years. In-row and between row spacing were adjusted in 2017 to increase air flow as a result of the *Fulvia* leaf mold observed in 2016. Plots were established by hand on 17 and 18 May in 2016 and 9 and 10 May in 2017. Plants were set to allow the graft union to remain approximately 1 inch above the soil line in the bed. Plants were trellised using the Florida Weave beginning at establishment and continuing through the growing season at approximately weekly intervals. Suckers were removed from below the graft union and from 1 -2 of the lowest leaf axils a few weeks after establishment.

Table 1. Summary of production practices in 2016, 2017, and 2018 trials

Year	In-row spacing	Between-row spacing	Plot size	Irrigation delivered	Rainfall for season (NOAA Knoxville airport)	Fertigation events
2016	2 ft. det. 3 ft. indet.	5 ft.	12 ft. det. 18 ft. indet.	12.7 inches	13.41 inches	10
2017	3 ft.	6 ft.	18 ft.	5.3 inches	18.24 inches	10
2018	3 ft.	6 ft.	18 ft.	6.3 inches	18.28 inches	11

No herbicides were used in plot management, but weed pressure was minimized by the use of plastic mulch and a woven black ground cover (2016) and straw (2017, 2018) in the isles. Disease pressure was minimized by applications of labeled fungicides (Serenade, Mancozeb, and Daconil) to control *Alternaria* and *Septoria.* Applications of Thuricide (Bt) and Spinosad were used to address yellow striped armyworms, while neem oil was used to address spider mites. Fertigation (20-10-20) soluble fertilizer was provided 10 times during the each growing season. Irrigation events were used to supplement rainfall, and higher irrigation levels were used in 2016. Combined estimated irrigation volume and rainfall were 26.11 for 2016, 23.49 for 2017, and 24.58 inches for the 2018 growing seasons, respectively.

Data collection and analysis:
In 2016, yield was collected from 11 harvests from 13 July through 31 August while there were 14 harvests in 2017 from 6 July to 26 August and 17 harvests in 2018 from 26 June to 31 August. All fruit per plot (generally harvested at USDA ripeness 4-6) were counted and sorted at each harvest. Useable fruit were counted and weighed and unusable fruit was counted and discarded. Sorting was done with the home gardener in mind. Data presented below are useable fruit that may have minor surface blemishes or small cracks, but does not have damage or decay that would prevent the use of the whole fruit. Data presented in Tables 2 and 3 represent the total weight and fruit number divided by the plants that were in the plots. The means separation used Least Square Difference test in a GLM model (SAS).

Results and Discussion

Table 2. 2016 Grafted and ungrafted beefsteak tomato yield

Scion	Rootstock	Weight/plant (lbs) (useable)	Avg. fruit weight (ounces)	Fruit # per plant (useable)	Useable %
Big Beef	Emperador	22.2 A	8.7 ± 0.2	41 ± 2	77%
Big Beef	Own	17.2 B	8.6 ± 0.5	32 ± 1	70%
Celebrity	Emperador	17.3 B	8.4 ± 0.2	33 ± 4	77%

Celebrity	Own	14.3 D	7.9 ± 0.2	29 ± 2	76%
Brandywine	Emperador	10.5 E	12.2 ± 0.6	14 ± 1	74%
Brandywine	Own	6.8 F	11.7 ± 0.4	9 ± 1	64%
Homestead	Emperador	14.6 CD	8.0 ± 0.3	30 ± 4	71%
Homestead	Own	9.7 E	6.3 ± 0.2	25 ± 1	76%

Table 3. 2017 Grafted and ungrafted beefsteak tomato yield

Scion	Rootstock	Weight/plant (lbs) (useable)	Avg. fruit weight (ounces)	Fruit # per plant (useable)	Useable %
Big Beef	Emperador	33.4 A*	8.2 ± 0.2	65 ± 6	86%
Big Beef	Own	27.2 B	7.4 ± 0.1	59 ± 4	86%
Celebrity	Emperador	30.2 AB	7.3 ± 0.3	66 ± 4	84%
Celebrity	Own	26.8 B	6.8 ± 0.1	63 ± 3	84%

Table 4. 2018 Grafted and ungrafted beefsteak tomato yield

Scion	Rootstock	Weight/plant (lbs) (useable)	Avg. fruit weight (ounces)	Fruit # per plant (useable)	Useable %
Big Beef	Emperador	27.3 A*	8.4 ± 0.2	52 ± 1	80%
Big Beef	Own	27.8 A	8.0 ± 0.6	57 ± 6	79%
Cherokee Purple	Emperador	21.7 B	10.5 ± 0.3	33 ± 4	68%
Cherokee Purple	Own	17.9 C	9.7 ± 0.3	30 ± 1	70%
Pineapple	Emperador	17.1 C	6.8 ± 0.5	41 ± 3	79%
Pineapple	Own	14.5 D	5.3 ± 0.2	43 ± 4	72%

* The same letters indicate statistically similar yields, while different letters represent statistically different yields. Useable yield per plant was the statistically analyzed data. The p value is 0.1, meaning there is a 90% or greater chance that these values are in fact different.

Useable fruit yield varied with harvest, grafting and scion cultivar as well as seasonally. In 2016, the harvest yield on 32 plots peaked on 1 Aug. (223 kg useable), remaining high on 4 Aug. (135 kg), 8 Aug. (150 kg), and 12 Aug. (156 kg) until dropping on 16 Aug. (101 kg), and 25 Aug. (98 kg) until 31 Aug. when a 38 kg harvest was determined to be the last due to decreasing yield. In 2017, the harvest yield on 16 plots stayed relatively high from 27 July (132 kg) through 7 Aug. (153 kg) before peaking on 10 Aug. (204 kg) and declining to only 38 kg on 26 August, which was the final picking. In 2018, the harvested yield from 24 plots peaked on 26 July (207 kg) on and declined relatively rapidly in August with all pickings from 31 July until termination on 31 August under 100 kg total.

Overall yields were highest in 2017, and this was likely due to higher rainfall and lower ambient temperatures. Additionally, the useable percentage of fruit was highest in 2017. There was also lower armyworm damage to the fruit in 2017 and 2018, but mite issues were likely more impactful in 2018. It should also be noted that these results were obtained in the absence of known pressure from soilborne diseases (*Fusarium, Vericillium*) for which there were differences in the trial in resistance in some of the ungrafted and grafted plants. So, any

yield differences are most likely due to physiological factors of root mass, nutrient or water uptake, and plant growth supporting increased fruit set or fruit production.

There were no interactions between scions and rootstocks in any of the three years, so results will be presented according to the grafting and cultivar treatments. In 2016, 'Big Beef' grafted was the highest yielding treatment. 'Big Beef' ungrafted yielded similarly to 'Celebrity' both grafted and ungrafted and grafted 'Homestead'. Grafted 'Homestead' yield was higher than ungrafted as was grafted 'Brandywine'.

In 2017, 'Big Beef' ungrafted was higher than its ungrafted comparison while there was no significant difference in grafted and ungrafted 'Celebrity'. In 2018, 'Big Beef' grafted and ungrafted yielded more than all other treatments. Grafted 'Cherokee Purple' and grafted 'Pineapple' yielded more than their respective ungrafted comparisons.

In 2016 and 2017, grafting treatments tended to produce more fruit and larger fruit than ungrafted. In 2018, there were no consistent trends toward more fruit, but individual fruit weight tended to be higher in grafted plots.

Summary of significance (at 0.1) of grafting in individual cultivars trials across all three years.

Was yield higher for grafted vs. ungrafted hybrid indeterminate cultivars?	Was yield higher for grafted vs. ungrafted hybrid determinate cultivars?	Was yield higher for grafted vs. ungrafted heirloom indeterminate cultivars?	Was yield higher for grafted vs. ungrafted heirloom determinate cultivars?
2/3 trials	0/2 trials	3/3 trials	1/1 trial

In both years when hybrid and heirloom were grown together, the hybrid cultivars yielded more. In general, heirloom cultivars responded with greater statistical yield for with grafting in all 4 trials (2016, 2018). Grafted hybrid cultivars produced greater yield than their ungrafted counterparts in only 40% on the trials, but indeterminate cultivars showed more potential for benefit than determinate. These results support the hypothesis that indeterminate tomatoes, specifically heirloom, may be supported by grafted rootstocks. However, additional cultivars should be trialed together to confirm these trends. Additionally, further work should be done to investigate a wider range of heirloom cultivars as well as potentially integrating differences in management (mulch, irrigation) in the same location to provide further information to assist home gardeners in cultivar selection and grafting utility.